



**science  
for the 21st  
Century**

# NUCLEAR ROCKETS

*will include continuing research into the advanced propulsion for space exploration*

Los Alamos has played an active role in the United States' manned space program — which reached its zenith with the Apollo 11 moon landing in 1969 — since its formative years. Future space missions, manned or unmanned, will require new technologies that can propel rockets and their payloads to other planets in the solar system or even other stars.

Research and development for space travel was a major scientific thrust at Los Alamos from the mid 1950s until about 1972. Project Rover — a joint effort between Los Alamos, the former Atomic Energy Commission and the National Aeronautics and Space Administration's Space Nuclear Propulsion Office — sought to build a nuclear reactor to power a rocket in space. Between 1959 and 1972, 23 reactors were built and tested by Los Alamos scientists.

The advantage of a nuclear rocket is its high exhaust velocity, which is more than two times greater than that of the engines on Space Shuttle rockets. The higher velocity translates into lower fuel mass of the ship in orbit and to faster trip times to planets.

Today, Los Alamos scientists are engaged in several efforts to develop new ways to test and build nuclear rockets. SAFE, or Subsurface Active Filtering of Exhaust, builds on technology developed in the nuclear weapons program. With SAFE, gases emitted from nuclear rockets are diffused underground into permeable subsurface rock. Los Alamos has requested \$10 million from NASA to test the SAFE process using a chemical rocket.

Los Alamos also collaborated with NASA's Marshall Space Flight Center in Huntsville, Ala., on a three-dimensional fluid dynamics computer model for a gas core nuclear rocket. If proven feasible, a gas core nuclear rocket would perform three times better than the solid core nuclear rocket developed during the Project Rover era. A gas core nuclear rocket still remains to be built and tested.

In a gas core nuclear rocket, cold hydrogen is pumped into the main axis of the rocket's engine. The hydrogen circulates creating a recirculation vortex in the chamber. Uranium particles are injected into the center of the vortex until the uranium accumulates to near-critical mass. After the chamber is stabilized, control drums in reflector walls rotate, driving the uranium to criticality. The now-hot uranium gas — temperatures approach 100,000 degrees Fahrenheit — radiates energy to the surrounding hydrogen, which exits through a nozzle to provide thrust.

Because of the extreme operating conditions in a gas core engine, design issues in fluid mechanics, materials, thermal load and radiation transport are at the state of the art or beyond. The gas core rocket development is a grand challenge commensurate with the capabilities of a national laboratory.

Scientists now must test and verify that the vortices in the gas core rocket can be formed and stabilized.

If the technology proves successful, a manned mission to Mars — some 200 times farther than the Moon — could be completed in nine months, versus an estimated three years using chemical rockets. Astronauts on such a mission would receive far less exposure to space radiation.

Development of a high performance nuclear rocket will enable humankind to finally break the bonds of Earth and gaze at undiscovered vistas throughout the solar system.

**CONTACT:** Steve Sandoval at [steves@lanl.gov](mailto:steves@lanl.gov) or (505) 665-9206. For more "Science for the 21st Century," go to <http://www.lanl.gov/orgs/pa/science21> on the World Wide Web.